MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

EME1046 – PRINCIPLES OF THERMODYNAMICS
(ME)

24 OCTOBER 2019
9.00 a.m –11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 printed pages (including cover page and appendix) with four questions.
2. Attempt **ALL FOUR** questions. Each question carries 25 marks.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.
5. A property tables booklet is provided.

Question 1

Air undergoes a thermodynamic cycle consisting of three processes as shown in **Figure Q1**:
Process 1–2: Isothermal expansion from $\mathbf{T_1}$ = 400 K, $\mathbf{P_1}$ = 6 bar, $\mathbf{V_1}$ = 0.03 m^3 to $\mathbf{V_2}$ = 3$\mathbf{V_1}$
Process 2–3: Constant volume to $\mathbf{P_3}$ where ($\mathbf{P_3} < \mathbf{P_2}$)
Process 3–1: Adiabatic compression to state 1.
There are no significant changes in kinetic or potential energy.
(Use $\mathbf{C_v}$ = 0.718 kJ/kg, **R** = 0.287 kJ/kg, **k** = 1.40)

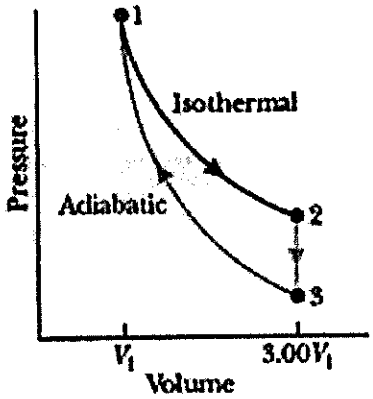

Figure Q1

a) Determine the mass of the air. [2 marks]
b) Determine $\mathbf{P_2}$, $\mathbf{P_3}$ and $\mathbf{T_3}$. [6 marks]
c) Calculate the heat transfer per unit mass, **q**, work output per unit mass, **w**, and change of internal energy per unit mass, Δ**u**, for each process in kJ/kg. [10 marks]
d) Calculate the net heat transfer per unit mass, $\mathbf{q_{net}}$, and net work output per unit mass, $\mathbf{w_{net}}$, for whole process in kJ/kg. [2 marks]
e) Is the net work output per unit mass of a closed system during a cycle equal to the net heat input per unit mass? Why? [3 marks]
f) Is this a power cycle or a refrigeration cycle? Explain your answer. [2 marks]

Question 2

a) Complete the blank cells in the following table of properties of <u>water</u>. In the last column describe the condition of water as compressed liquid, saturated liquid, saturated liquid- vapor mixture, saturated vapor, superheated vapor, or insufficient information; and, if applicable, give the quality.

P, kPa	T, °C	v, m^3/kg	u, kJ/kg	Quality, x	Condition description
100	70				
200					saturated vapor
20,000	40				
400			3170.5		
	120		2022.6		

[13 marks]

Continued ...

b) A Carnot heat engine receives heat from a reservoir at 900 °C at a rate of 800 kJ/min and rejects the waste heat to the ambient air at 27 °C. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at -5 °C and transfers it to the same ambient air at 27 °C. Determine

i) The maximum rate of heat removal from the refrigerated space and [7 marks]

ii) The total rate of heat rejection to the ambient air. [5 marks]

Question 3

A hot-water stream at 80°C enters a mixing chamber with a mass flow rate of 0.5 kg/s where it is mixed with a stream of cold water at 20 °C as shown in **Figure Q3**. Assume all the streams are at a pressure of 250 kPa. If it is desired that the mixture leave the chamber at 42 °C, determine

a) the enthalpy of hot-water stream, [3 marks]

b) the enthalpy of cold-water stream, [3 marks]

c) the enthalpy of mixture leave the chamber, [3 marks]

d) the mass balance equation, [4 marks]

e) the energy balance equation, and [8 marks]

f) the mass flow rate of the cold-water stream. [4 marks]

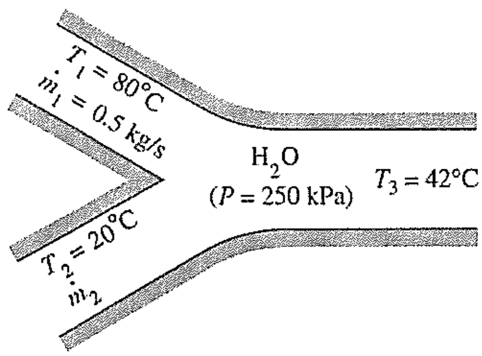

Figure Q3

Continued ...

Question 4

A 0.5-m^3 rigid tank contains refrigerant-134a initially at 200 kPa and 40 percent quality. Heat is transferred now to the refrigerant from a source at 35 °C until the pressure rises to 400 kPa. Determine

a) initial internal energy,

[2 marks]

b) initial entropy,

[2 marks]

c) initial specific volume,

[2 marks]

d) final internal energy,

[2 marks]

e) final entropy,

[2 marks]

f) mass of the refrigerant,

[3 marks]

g) the entropy change of the refrigerant,

[3 marks]

h) the entropy change of the heat source, and

[6 marks]

i) the total entropy change for this process.

[3 marks]

Continued ...

Appendix

Uniform State Uniform Flow (Unsteady Flow)

Continuity:

$$(m_2 - m_1) = \sum_i m_i - \sum_e m_e$$

First Law:

$$Q_i + W_i + \sum_i m_i\left(h_i + \frac{V_i^2}{2} + gZ_i\right) - Q_e - W_e - \sum_e m_e\left(h_e + \frac{V_e^2}{2} + gZ_e\right)$$
$$= m_2\left(u_2 + \frac{V_2^2}{2} + gZ_2\right) - m_1\left(u_1 + \frac{V_1^2}{2} + gZ_1\right)$$

Second Law:

$$m_2 s_2 - m_1 s_1 = \sum_i m_i s_i - \sum_e m_e s_e + \int_0^t \frac{\dot{Q}_{cv}}{T} dt + {}_1S_{2\,gen}$$

Ideal Gas

Ideal Gas Equations of State

$$Pv = RT$$
$$dh = C_p dT$$
$$du = C_v dT$$

Specific Heats and Ideal Gas Constants

$$C_p - C_v = R$$
$$\frac{C_p}{C_v} = k$$

Entropy Relationships

$$\begin{aligned} s_2 - s_1 &= C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} \quad \text{if constant } C_v \\ &= C_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} \quad \text{if constant } C_p \\ &= s^0_{T_2} - s^0_{T_1} - R\ln\frac{P_2}{P_1} \quad \text{otherwise} \end{aligned}$$

For polytropic process

$$PV^n = constant, \quad TV^{n-1} = constant, \quad TP^{\left(\frac{n}{n-1}\right)} = constant$$

$$\begin{aligned} {}_1W_2 &= \frac{P_1V_1 - P_2V_2}{n-1} = \frac{mR(T_1 - T_2)}{n-1}, \quad n \neq 1 \\ &= P_1V_1 \ln\left(\frac{V_2}{V_1}\right), \quad n = 1 \end{aligned}$$

End of Paper.